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CONCEPTUAL DESIGN OF A 4-GeV HEXAGONAL MICROTRON*

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This paper describes a higher-order variant of the microtron which offers an attractive option for furnishing c.w. electron beams at 4 GeV. The accelerator is a six-sided microtron consisting of three dispersive straight sections and three dispersion-free straight sections of constant length where three linacs are located.

The synchronization condition is given by the relation

$$(\pi/3 - \sin \pi/3)2\Delta\rho = \lambda \quad , \tag{1}$$

where $\Delta\ell$ is the increase per turn of the radius of curvature and λ is the rf wavelength. In general, the velocity of the electrons is close enough to the velocity of light (c) that the following approximation is sufficiently accurate

$$\Delta\rho = \frac{\beta\Delta W + W\Delta\beta}{eBc} \approx \frac{\Delta W}{eBc} \tag{2}$$

where ΔW is the energy gain per turn, $\Delta\beta$ is the corresponding increase of the electron velocity in units of the light velocity c, and B the flux density of the bending magnet. Letting in Eq. (1), $\lambda = 0.125$ m, we obtain

$$\Delta\rho = 0.345 \text{ m} \quad . \tag{3}$$

The maximum energy of the electrons is given by

$$W_{max} = W_i + n_{max} \frac{\Delta W}{3}$$

Choosing the injection energy $W_i = 185$ MeV (NBS-LASL microtron) and the energy gain per linac $\Delta W/3 = 35$ MeV we obtain $n_{max} = 109$ (36-1/3 turns). Substitutions of Eq. 3 and $\Delta W = 105$ MeV in Eq. 2 give B = 1.015 T.

The energy, the radius of curvature and the flux density are related by the equation

$$\rho = \frac{W\beta}{eBc} \quad . \tag{4}$$

Letting $\beta = 1$ and B = 1.011 T, we obtain

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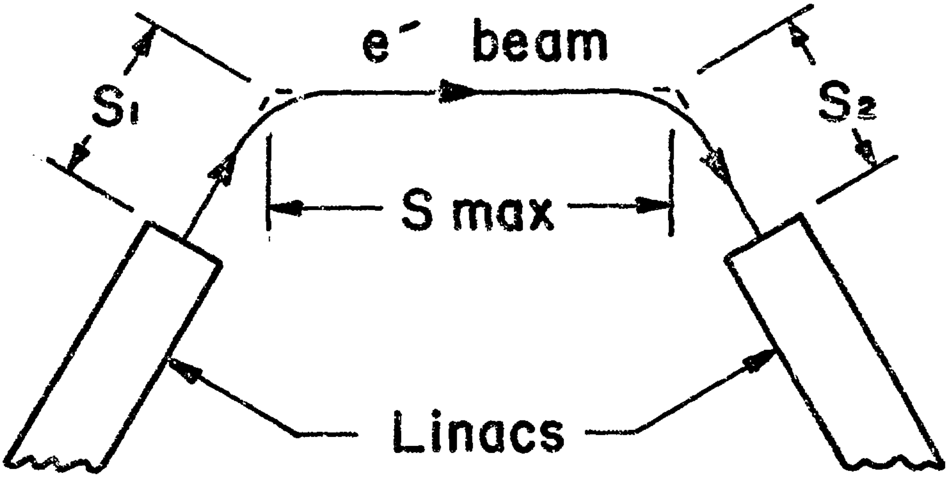

Fig. 1

$$\rho_i = \frac{W_i}{eBc} = 0.608 \text{ m}$$

$$\rho_{max} = \frac{W_{max}}{eBc} = 13.145 \text{ m}$$

With S_{max}, S_1 and S_2 as shown in Fig. 1 we obtain the initial synchronism condition

$$S_1 + S_2 + S_{max} + (\pi/3 - \sin \pi/3)2\rho_i = \mu_i\lambda \qquad (5)$$

Choosing $S_1 + S_2 = 3$ m and $\mu_i = 255$ we obtain $S_{max} = 28.655$ m. For a linac length of 25 m we find L = 28 m where L is the length of the dispersion-free straight section. These were selected to make over-all dimensions compatible with an existing tunnel.

Noting that the energy gain per linac $\Delta W/3 = eV \cos \phi_s$, one can show that synchronous phase and synchrotron tune are related as follows:

$$\cos \frac{2\pi}{3} \nu_s = 1 - \frac{\pi}{3} \tan \phi_s \qquad (6)$$

Substituting Eq. 6 in the stability limit requirement:

$$-1 > \cos \frac{2\pi}{3} \nu_s < +1$$

we find

$$0 < \tan \phi_s < 6/\pi \quad \text{or} \quad 0 < \phi_s < 62.36^0$$

Substitution of $\phi_s = 18^0$ in Eq. 6 gives $\nu_s \approx 0.405$. The basic design parameters for the "Hexatron" are presented in Table I.

TABLE I
Basic Design Parameters

Maximum Energy	4000 MeV
Injection Energy	185 MeV
Current	300 μA
Magnetic Field	1.015 T
Maximum Orbit Radius	13.145 m
Minimum Orbit Radius	0.608 m
Energy Gain Per Turn	105 MeV
RF Wavelength	0.125 m
Synchronous Phase	18° ($\nu_s \approx 0.4$)
Longitudinal Stability Limit	62.4°
Accelerating Field	1.47 MV/m
Energy Gain Per Linac	35 MeV
Number of Linacs	3
Length of Linacs	25 m
Length of LSS	28 m
Orbit Separation in SSS	0.1725 m
Orbit Length Increase Per Turn	$3\lambda = 0.375$ m
Maximum Number of Recirculations	36-1/3